Journal of Archaeological Science: Reports xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Multi-element and biomolecular analyses of soils as a means of sustainable site structure research on hunter–gatherer sites: A case study from the Canadian Arctic

Don H. Butler [a,b,*], Angelica Lopez–Forment [c], Peter C. Dawson [a]

[a] University of Calgary Department of Anthropology and Archaeology, 2500 University Drive NW Calgary, Alberta T2N-1N4, Canada
[b] University of Haifa Department of Maritime Civilizations, 199 Abba Khoushy Ave, Haifa, Israel
[c] Consulting Archaeologist, Canada

ARTICLE INFO

Article history:
Received 7 July 2015
Received in revised form 15 October 2015
Accepted 29 November 2015
Available online xxxx

Keywords:
Hunter–gatherers
Canadian Arctic
Soil chemistry
XRF
ICP-MS
FTIR
PCA
IDW
Site structure
Sustainable archaeology

ABSTRACT

Analyses of large open-air spaces on northern hunter–gatherer sites face many difficulties. A central concern is that open-air tasks such as large scale animal processing may leave behind little or no macro evidence. Many tasks did, however, introduce chemical residues into underlying soils. Chemical surveys of these soils offer a minimally invasive, sustainable means of investigating large open-air spaces, which can provide evidence for the structured use of such spaces. Defining structuring in the use of space, in turn, contributes to clarifying site functions, seasonality, and residential mobility. Exemplifying this approach, we present results from ongoing soil chemistry studies at a 2000 year old Taltheilei hunter–gatherer encampment in the Canadian Arctic. Samples were analyzed using X-ray florescence spectroscopy (XRF), inductively coupled plasma-mass spectroscopy (ICP-MS), and Fourier transform infrared spectroscopy (FTIR). Patterning in the data was highlighted using principal component analysis (PCA) and inverse distance weighted interpolation (IDW). Anomalous concentrations of CaO, MnO, P_2O_5, and Cu were discovered adjacent to dwellings, representing hearth cleaning episodes. Along with these, enrichments in K_2O, MgO, Fe_2O_3, Sr, Sc, Y, Cr, Ni, and Pb provide support for the presence of open-air animal processing facilities. We have also identified several peaks in our FTIR spectra that reasonably indicate trans-fat derived from ruminant tissue. At this stage of research, anomalies are attributed to caribou processing and refuse disposal during late fall occupations. While we are hopeful that FTIR will continue to develop as a valuable means of identifying fats in archaeological contexts, additional work will strengthen our current argument for the presence of trans-fats in our samples.

1. Introduction

The growth of archaeological soil chemistry throughout the past 25 years has provided important contributions to our understandings of past human behaviours across diverse geographic, temporal, and cultural contexts (e.g., Davidson et al., 2006; Milek and Roberts, 2013; Rondelli et al., 2014; Salisbury, 2013; Sarris et al., 2004; Sampietro and Vattuone, 2005; Simpson et al., 2000; Sullivan and Kealhofer, 2004; Wells, 2004). Over the past decade we have witnessed renewed productivity in soil chemistry research on hunter–gatherer sites in the Arctic regions of North America. This attention has developed from an increased appreciation for the quality of anthropogenic chemical records in the region's soils (Knudson et al., 2004), an amplified interest in clarifying the use and organization of open-air spaces (Butler and Dawson, 2013), and a growing responsibility for developing sustainable methodologies suited to fragile, rapidly changing Arctic environments (Misarti et al., 2011).

Cryosols across Canadian Arctic regions have chemical and physical properties favourable to the preservation of anthropogenic chemical additions. The annual average temperature of cryosols in the Canadian Low-Arctic is 0 °C, a result of permafrost, seasonal freezing, low-lying vegetation, flat topography, and exposure to wind (Bockheim et al., 2006; Tarnocai, 1980). This persistently low temperature reduces chemical weathering and element mobility, microbial activity, and leaching. It also limits plant productivity and nutrient uptake (Knudson et al., 2004; Misarti et al., 2011). Humic cryosols are characterized by finer textures, lower bulk densities, higher porosities, and high percentages of organic matter, and thus both imperfect drainage and higher cation exchange capacities (CSCWG, 1987). Together, these properties increase the likelihood that sites in locations characterized by such soils will contain relatively well preserved anthropogenic chemical records (Entwistle et al., 2007; Middleton, 2004; Oonk et al., 2009; Salisbury, 2013; Wells, 2010; Zgłobicki, 2013). Under such circumstances, chemical archives can rapidly form beneath hunter–gatherer workspaces (Knudson et al., 2004), and they can be retained for lengthy durations (Misarti et al., 2011). Owing to this enhanced probability of survivorship, sites in the Arctic regions provide apt field laboratories for testing the merits and limitations of newer

* Corresponding author at: University of Haifa Department of Maritime Civilizations, 199 Abba Khoushy Ave, Haifa, Israel.
E-mail address: dhbutler@ucalgary.ca (D.H. Butler).

http://dx.doi.org/10.1016/j.jasrep.2015.11.030
2352-409X/

methodologies such as portable XRF and infrared microscopy, for testing hypotheses developed from ethnoarchaeological and experimental studies, and for realizing high resolution investigations of the organization of open-air spaces.

In our experience, past archaeological research in northern Canada has focused much more on site feature and regional scales of analyses, as these scales provide abundant data. Far less attention has been afforded to large open-air spaces at the site level, a result of the perception that very little material culture and macro-refuse may exist across the spaces between the visible features comprising hunter–gatherer sites. This is certainly true in many cases. Micro-archaeological studies, however, have thoroughly demonstrated that evidence for human habitation can be extracted from places lacking facilities, features, artifacts, refuse, and so on (Entwistle et al., 2007; Oonk et al., 2009; Weiner, 2010). Soil chemistry provides some of the tools required to locate and characterize different types of facilities and activities that are largely invisible to routine archaeological investigations. For instance, recent fish drying racks in Alaska, facilities that may leave behind very little macro-evidence, have been found to influence the element compositions of soils at their bases (Knudson et al., 2004; Knudson and Frink, 2010). These types of data contribute to decoding functions, residencies, and seasonalities of northern hunter–gatherer sites (Misarti et al., 2011).

There is also a rising interest in developing sustainable, less invasive archaeological methodologies in Arctic settings. This relates to our growing awareness of heritage resources facing risk arising from the fragility of this rapidly changing ecosystem (Barr, 2008, 2009; Blankholm, 2009; Dawson et al., 2013; Ford et al., 2006). Site-wide soil core surveys and chemical analyses supply a minimally invasive means of assessing the use and organization of open-air spaces on Arctic sites and for comparative analyses of the use of open and enclosed spaces. Our previous research using soil coring at the Ikirahak site off the west coast of Hudson Bay in northern Canada allowed us to discern refuse disposal practices, in turn developing an additional layer of evidence pointing toward longer term occupations at the camp (Butler and Dawson, 2013). Misarti et al. (2011) have also advocated for the development of less invasive archaeological methodologies applicable in Arctic settings. Their coring programmes at several sites in the Aleutian Islands of Alaska provided abundant evidence for site specific subsistence practices and occupation intensities.

Here, we contribute to this developing body of research on northern hunter–gatherer soil chemistry by exploring the approach as a form of sustainable archaeology, and more specifically, by demonstrating the value of site-wide soil chemistry surveys for clarifying site structures. Evidence for the use and organization of space is valuable in studies of site functions, durations/intensities of occupation, and site seasonality. We exemplify our position using integrated multi-element XRF/ICP-MS and biomolecular FTIR analyses from the Ikirahak site, a 2000 year old Taltheilei culture site in the Canadian Arctic.

2. Sustainable hunter–gatherer site structure research

Sustainability, at its core, has the goal of developing consumption strategies that realize the needs of current generations while not obstructing the capacity of future generations to fulfill their needs (Solow, 1991). Sustainability in archaeology has commonly been discussed in terms of community/public archaeology, citizen science, salvage archaeology, risk mitigation, and heritage resources management (Sabloff, 2008; Smith, 2014). Another important avenue involves developing and implementing non/minimally invasive methodologies (Dawson et al., 2013; Nolan and Redmond, 2015). Sustainable archaeologies aim to maximize the amount of information extracted from the archaeological record, contributing to filling gaps in current archaeological knowledge, while at the same time protecting the record so it may serve a variety of purposes among generations to come.

Archaeological site structures comprise formation processes, macro and micro assemblages, activity areas, features, facilities, dwellings, and many other types of culturally specific things that are spatially organized in ways guided by physicalities, histories, socialities, and ideologies (Binford, 1983; Carr, 1984; O'Connell, 1987; Wandsnider, 1996). These types of evidence have been used to address a diversity of questions, such as those concerning the use of space, site functions, residential mobility, seasonality, social interactions, and ideologies, along with continuity and change in these variables (Butler, 2011; Frink, 2007; O'Connell et al., 1991; Simms, 1989; Whitridge, 2004).

Analyses of hunter–gatherer site structures face many difficulties. In terms of sustainable archaeology, our central concern involves the great scale of excavations that may be necessary, and moreover, these excavations may only capture a portion of the entire site, or there may be little macro-evidence available (O'Connell, 1995; Simms, 1987; Wells, 2010). It may not be feasible to excavate large portions of sites because of time, personnel, and budget constraints. This is particularly true for research on hunter–gatherer sites in the Arctic regions. Largely owing to such restraints, open-air spaces are not commonly investigated in these places. Nor, for ethical reasons, our duty of stewardship, do we necessarily want to excavate large portions of sites. We must balance these concerns to continue advancing studies of site structures. One way of moving forward is to develop methods for extracting more information from smaller areas (Hill et al., 2011). An additional approach is to focus on larger areas using less invasive soil chemistry (Butler and Dawson, 2013; Misarti et al., 2011; Zgłobicki, 2013). This approach provides a sustainable method of investigating large areas, maximizing the amount of information extracted, while also imposing negligible impact.

Concerning northern areas in specific, less invasive, expedited methodologies such as small bore soil coring provide a means of studying expansive spaces at sites that are threatened by erosion and melting permafrost. Using this approach, we will learn as much about threatened sites as possible in short periods of time while also minimizing contributions to any detrimental influences these sites may be experiencing. Soil survey research will decrease the amount of time spent on sites, in turn reducing foot traffic and associated erosion. When excavation is unavoidable, soil chemistry surveys will direct us to high potential areas, in turn circumventing the implementation of much more invasive test excavation strategies (Entwistle and Abrahams, 1997; Middleton et al., 2010; Misarti et al., 2011). Below, we explore the types of information provided by minimally invasive soil coring and integrated multi-element and biomolecular analyses at the Ikirahak site.

3. Study site

3.1. The Ikirahak environment

The Ikirahak site (JjKs-7) is located in the Central Canadian Low-Arctic off the west coast of Hudson Bay in the Maguse River Upland ecoregion (Fig. 1) (Environment Canada, 2013). More specifically, the site is located on Ikirahak Island in Maguse Lake. The region is in the Churchill Geological Province of the Canadian Shield, which is characterized by large areas of granites, granodiorites, quartz diorites, quartz monzonites, schists, and gneisses (Donaldson, 1986). Maguse Lake is surrounded by an Archaean unit comprised of andesite, basalt, rhyolite, volcanic breccia and tuff, greenstone schist, and amphibole gneiss (Arsenault et al. 1980). Geomorphologically, the region is characterized by hummocky bedrock outcrops, discontinuous sandy and granitic tills, expansive fluvio-glacial esker systems, surfical cryoturbic features related to permafrost, and widespread wetlands (Environment Canada, 2013). Ikirahak Island itself is an esker deposited during the retreat of the Laurentide Ice Sheet in the Keewatin Ice Divide region (Aylsworth and Shilts, 1989; Shilts, 1986). The study site is over 200 km north of